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Do Cesarean Delivery rates rise when the economy declines? A test of the economic stress hypothesis

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ABSTRACT

A growing body of research supports the Barker hypothesis that adverse conditions around the time of birth have a negative effect on health. Nevertheless, the mechanisms linking early life conditions with health are still unclear. This paper investigates one of such potential mechanisms, specifically, ambient stress, by analyzing the effect of economic downturns as a stressor on the probability of Cesarean Delivery (CD). I focus particularly on male CD since the literature reports that male fetuses are more sensitive to stressors in utero than female fetuses. Using data from *Lifelines*, a large cohort study from the northern Netherlands, I show that the probability of CD for male babies increases when unemployment levels rise. This result suggests that maternal stress might be one of the mechanisms how early life economic conditions affect health.

1. Introduction

A growing body of research supports the Barker's hypothesis (Barker, 1995), that adverse economic conditions around the time of birth have a negative effect on a variety of health outcomes over the lifetime (Alessie et al., 2018, 2019; Olafsson, 2016; Dehejia and Lleras-Muney, 2004; Case et al., 2005; Case and Paxson, 2010; Van den Berg et al., 2006, 2009, 2011 and 2013; Angelini and Mierau, 2014). The studies exploring the mechanisms behind these effects suggest malnutrition, changes in cohort composition and health behaviors of the parents as potential explanations of the effects (e.g. Dehejia and Lleras-Muney, 2004; van den Berg et al., 2006, 2009, 2011). In addition, some recent findings suggest that stress caused by economic problems might have direct health effects on pregnant women and fetuses (Alessie et al., 2018; Olafsson, 2016; Bruckner et al., 2014). To test this economic stress hypothesis, Bruckner et al. (2014) investigate the relationship between business cycles and the number of cesarean deliveries (CD) by a time series analysis using data on the monthly count of male CD in California from 1989 to 2007 and total state employment. They find that male CD increases above its expected value when employment declines, as male fetuses are more sensitive to adverse conditions *in utero*.

This paper also examines whether stress caused by economic downturns affects the pregnant women severely enough to increase the probability of Cesarean Deliveries (CD) for male babies. My paper adds to the findings of Bruckner et al. (2014) and the related literature in several ways.

First, similarly to Bruckner et al. (2014), this paper provides evidence on the importance of stress as a transition mechanism between ambient economic conditions early in life and health outcomes. The literature provides ample evidence that macro-economic conditions may prove stressful enough to affect health and behavior. Responses to economic downturns include stressful economic (e.g., job loss, difficulty paying bills) and noneconomic (e.g., family problems, change of residence) life events. Additionally, following economic downturns, mental health and self-reported health, reportedly, worsens even among those who do not lose jobs (Ferrie et al., 1995; Vahtera et al., 1997). Likewise, reductions in cognitive ability and ability to perform simple daily tasks have been observed in individuals facing financial pressures (Andreoni et al., 2017; Mani et al., 2013). In sum, this suggests that economic downturns may lead to substantial maternal stress. In turn, biologically, feeling stressed may increase corticosteroid production in pregnant mothers and this can cause non-reassuring

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fetal heart rate or "fetal distress" (Owen and Matthews, 2003; Matthews et al., 2002). Following obstetric care guidelines, a physician who observes fetal distress during pregnancy or labor may decide to perform a CD (Bruckner et al., 2014; Hendrix and Chauhan, 2005).

Second, this study adds to the growing evidence on gender specific health effects of early life conditions. Reportedly, male fetuses greater than 20 weeks of gestation react more sensitively than female fetuses to maternal corticosteroids (Owen and Matthews, 2003; Matthews et al., 2002; Van den Berg and Modin, 2013; Catalano et al., 2005 and 2010). In a related line of literature, evidence from California, Sweden, and Germany shows that the secondary sex ratio (e.g. the ratio of male live births vs. female live births) falls following declines in the economy (Catalano, 2003; Catalano and Bruckner, 2005; Catalano et al., 2010; Almond and Mazumder, 2011). If stress has a similar effect on the risk of male fetal loss as on the risk of fetal compromise, then, following stressful events, CD in male fetuses may increase more than in female fetuses.

Third, I use individual level data containing information on the date and manner of birth from a large-scale cohort study from the Northern Netherlands, called *Lifelines*. This has two advantages compared to the aggregate approach of Bruckner et al. (2014). Most importantly, it allows me to increase the precision of the estimates by using a sample of individuals born only in the weekends or holidays. Since CDs caused by fetal distress in reaction to maternal stress cannot be planned beforehand, this paper considers only the effect of unemployment level on unplanned CD. By design, Bruckner et al. (2014) are not able to distinguish between unplanned and planned CD in their data, which means that a large part of the observed CDs are driven by factors other than stress.[1] This may lead to underestimation of the effect and large standard errors. To address this issue, I exploit the fact that a planned CD in the Netherlands is routinely scheduled during regular working hours, e.g. on weekdays. Hence, I select a subsample of individuals who are born in the weekends and Dutch public holidays, which lets me exclude the planned CDs from the analysis and, possibly, obtain estimates that are more precise.

Another advantage of the individual level data is that it lets me investigate if the results are driven by selective fertility. Previous literature has shown that the relationship between unemployment rates and infant health can partially be explained by changes in cohort composition or health-related behaviors (e.g. Dehejia and Lleras-Muney, 2004; Alessie et al., 2018). Since socio-economic gradient has been found in CD probabilities in the Netherlands (Westert et al., 2003), it is conceivable that the relationship between unemployment rates and the probability of CD might also be driven by changes in the cohort composition of the pregnant women. I exploit the parental information available in the *Lifelines*, namely the mother's age and smoking status during pregnancy, as well as parental immigrant status to provide suggestive evidence that my results are not driven by selective fertility during economic downturns.

Finally, Netherlands might be a particularly interesting country for investigating the effects of maternal stress due to its distinctive institutional setting. The Dutch obstetrical care system is unique in that it is characterized by a well-defined distribution between primary and secondary care, which results in low CD rates overall[2] (Amelink-Verburg and Buitendijk, 2010). In general, since CD is costlier than a vaginal delivery, the medical specialists and hospitals might respond to financial incentives and recommend more CDs when facing financial pressures, for example, during recessions. However, the delivery guidelines in the Netherlands limit the opportunities for supplier-induced demand or delivery on demand. Another institutional feature of the Netherlands is its generous unemployment insurance that limits the effects of job loss on income and consumption of pregnant women.[3]

The rest of this paper is set up as follows. In the following section, I present the data. Section 3 describes my empirical strategy and methods. In Section 4, I present and discuss the results, and the final section concludes.

2. Data

To test my hypothesis that stress caused by high unemployment levels at the time of birth increases the probability of CD in male babies more than in female babies empirically, I analyze the relationship between provincial unemployment level and the individual probability of CD in the Netherlands. In particular, I combine the individual data from the *Lifelines* cohort study with the unemployment data from Statistics Netherlands.

2.1. Lifelines

Lifelines is a large population-based cohort study and biobank carried out in the three north-eastern provinces of the Netherlands. The study was established as a resource for research on complex interactions between environmental, phenotypic and genomic factors in the development of chronic diseases and healthy ageing (see Stolk et al. (2008) and Scholtens et al., (2015), for a detailed description of the study). Overall, Lifelines covers more than 10% of the population in the Dutch provinces of Groningen, Friesland and Drenthe. Klijs et al. (2015) studied the representativeness of the Lifelines sample and concluded that the sample is broadly representative of the population of the northern Netherlands.

2.2. Sample selection

For my purposes I select a sample of individuals from *Lifelines* study who are born in the Netherlands between 1970 and 1993 and have provided the information about their birth. *Lifelines* also contains respondents born before 1970; however, before 1970 the CD rates in the Netherlands and in the world in general were very low and they started to increase only in the early 1970s due to introduction of the electronic fetal monitoring (EFM) technology. EFM allowed monitoring the heart rate of the fetus continuously before and during labor to detect deteriorating fetal wellbeing and intervene before neurological damage takes place in the fetus (Elferink-Stinkens et al., 1992). The upper limit of the birth year is caused by the fact that *Lifelines* only provides answers from individuals older than 18 at the time of interview. The baseline interviews were carried out between 2007 and 2012. The outcome variable is based on the answers to the question: "How were you born?" with answer options: "Normal vaginal delivery / Cesarean section / Operative vaginal delivery (with vacuum or forceps) / Don 't know". Less than 1% of the sample is excluded due to the answer "don't know". This results in an initial sample of 31,863 individuals. Since the information about birth is self-reported, measurement error is a potential concern. Compared to the population data (see Elferink-Stinkens et al., 1992), the rates of CD (Fig. 1) in the Lifelines sample are lower, suggesting that the CD might be underreported which might lead to underestimation of the effect of regional

[1] For example, previous CD, physical incompatibility between mother's pelvis and the baby, breach position, etc.

[2] See the Appendix A for a detailed description of the Dutch obstetric care system.

[3] See Becker (2000) for a discussion of the Dutch welfare state and employment.

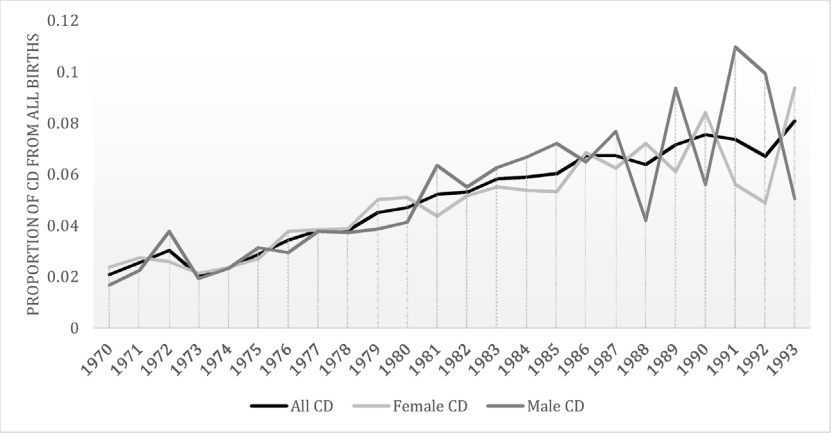

Fig. 1. Cesarean Delivery Rates in the Lifelines Sample, all days.1970–1993.

unemployment. Further, the estimation strategy is based on the assumption that the measurement error is not correlated to the regional unemployment level as such correlation could potentially bias the estimation results (Wooldridge, 2010).

Next, I am mainly interested in the effect of unemployment level on unplanned CD, since only the unplanned CDs can be caused by fetal distress in reaction to maternal stress. In my data, I am not able to distinguish between unplanned and planned CD which means that a large part of the observed CDs are driven by other factors than stress (e.g. previous CD, physical incompatibility between mother's pelvis and the baby, etc.). This may lead to underestimation of the effect and large standard errors. To address this issue, I exploit the fact that a planned CD is normally scheduled during regular working hours, e.g. on weekdays. Hence, I select a subsample of individuals who are born in the weekends and Dutch public holidays, which are New Year, Easter, Queen's day, Ascension Day, Pentecost and Christmas. I perform the analysis in both, the full sample and the weekend / holiday subsample with the expectation that the weekend/holyday subsample yields larger coefficients and more precise estimates.

Finally, since this paper attempts to establish whether the effect of unemployment might be (partially) explained by cyclical changes in the cohort composition, I need to include proxies of socio-economic status (SES) in my model. Unfortunately, even though *Lifelines* provides ample information on the SES of the individual itself, the information on the SES of the family into which the individual is born is very limited. Nevertheless, three pieces of information on parental characteristics are available, such as mother's age at childbirth and smoking status during pregnancy as well as whether parents were born outside the Netherlands. The mother's age, apart from having a biological effect on the probability of CD (Ecker et al., 2001), might also serve as a proxy for SES of the parents, since early entry into motherhood is associated with lower SES (Hobcraft and Kiernan, 2001). Second, smoking in general and especially smoking during pregnancy has been shown to be correlated with SES (see, for example, reviews in Cutler and Glaeser, 2005; or Cutler and Lleras-Muney, 2006). Third, families where at least one parent was born outside the Netherlands have, on average, lower SES and higher healthcare utilization levels (Reijneveld, 1998; Stronks et al., 2001). Even though these variables do not cover all possible changes in cohort composition, they provide suggestive evidence on the importance of changes in cohort composition during economic downturns. Excluding observations with missing values in these maternal characteristics leaves me with 28,010 observations in the sample with all births and 7573 observations in the subsample with only weekend and holiday births.

Understandably, the most data is missing from the variable denoting mother's smoking status (missing for about 11% observations) as this is very specific information that many respondents are not able to provide about their mothers. In general, the missing values stem from individuals who are on average, slightly older, less educated and more likely to be male than my final sample (see Appendix B for the descriptives). Due to male fetal sensitivity, I would expect that the effects of economic downturns are larger in males. Also, low SES families might be more sensitive to the effects of economic downturns. If the education level of the individuals in the sample is correlated to the SES of their parents, I would also expect larger effects of the unemployment at birth on the probability of CD in the sample with missing values. Hence, it is possible that the estimates from my main sample are downwards biased and can be considered conservative.

As mentioned before, the Lifelines sample is broadly representative of the "current" population of the northern Netherlands. Since this paper focuses on the retrospective information about the individuals' birth, this leads to some potential selection issues. First, since data is gathered only in the three northern provinces, everyone who is born in any other province, has migrated to the northern provinces. This demands controlling for the province of birth in the econometric specification. Second, some individuals might be born in the northern provinces but migrated away after birth. The northern Netherlands was hit harder by the economic crises in the 1970s and 1980s than other provinces. If those affected most by the increasing unemployment are more likely to migrate away, the results might be underestimated. Finally, some individuals might have died before the data collection. If those who are most affected by the economic conditions at birth have a higher mortality rate, my results could be underestimated and could be considered conservative.

Fig. 1 presents the proportion of births via CD per year of birth and gender from the sample with all births. We can observe an increasing trend in the CD rates over time which echoes the global trends in CD rates in this time period. The large fluctuations in the CD rates in the last periods in Fig. 1 can be attributed to the smaller sample size in these birth years.

The proportion of CD births over time in the sample with weekend and holiday births is depicted in Fig. 2. The slope of the trend in weekend CD rates in the sample seems flatter than in the total CD rates (Fig. 1), which is in line with the findings by Elferink-Stinkens et al. (1992). They show that, in the Netherlands, the large increase in CD comes mostly from the increase in planned CD and not from emergency CD caused by fetal distress. In the context of this paper, it is possible, that some pregnancies, that could have

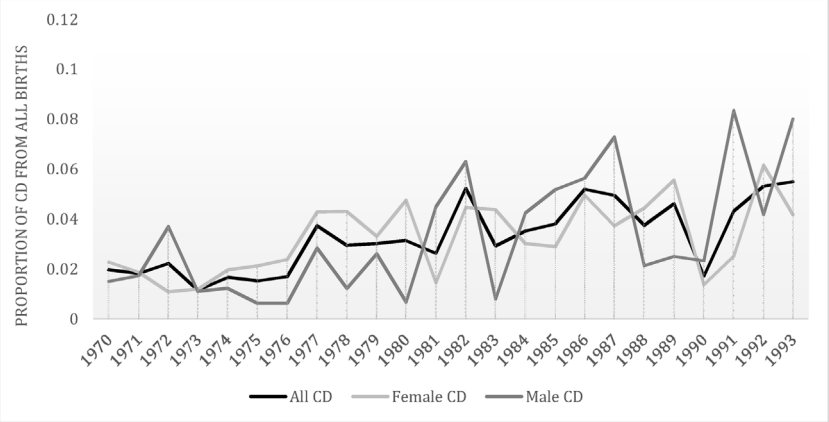

Fig. 2. Cesarean Delivery Rates in the Lifelines Sample, only births on weekends and public holidays.1970–1993.

ended in a stress-induced CD, actually result in a planned CD which might lead to underestimation of the stress-response.

In addition, all other descriptive statistics for both samples are summarized in Tables 1A and 1B. Due to the *Lifelines* study design – the participants volunteer to participate via their family doctor – *Lifelines* contains more women than men in the sample. Also, in the weekend and holiday sample (Table 1B) a bigger proportion of women report being born via CD than men; however, this difference is not statistically significant. This suggests some possible underreporting of CD among men. As discussed above, I assume that such measurement error is not correlated to the regional unemployment rate, since such correlation might bias the results. As expected, the proportion of CD is higher in the whole sample than in the weekend and holiday subsample, since the whole sample includes also the planned CDs. In all other descriptive characteristics the two samples are very similar.

Since the *Lifelines* itself does not contain information about the place of birth, I link the *Lifelines* data with the birth certificate information from the Municipal Personal Records Database (in Dutch: *Gemeentelijke Basis Administratie*) to obtain information on the province of birth of each respondent. Since the *Lifelines* study is based in the north-eastern Netherlands, the three north-eastern provinces (Groningen, Drenthe and Friesland) are overrepresented. Yet, the data includes respondents born in all twelve Dutch provinces.

2.3. Provincial unemployment

I link the province and year of birth information to the provincial unemployment rates in the given year. The unemployment rate provides me with a contextual variable that serves as a proxy of the economic conditions under which the individual was born without suffering from the endogeneity of individual level socioeconomic indicators. Provincial unemployment data is drawn from Statistics Netherlands and presented in Fig. 3. During my period of interest, the Netherlands went through all phases of the business cycle. At the end of the 1970s and for much of the early 1980s, the country suffered a strong recession due to the second oil crisis. This recession was particularly strong in the northern provinces of the Netherlands where unemployment exceeded 10% at the peak of the recession. In the early 1990s, unemployment rates dropped significantly all over the country. The data displays variation over time and between provinces, which provides me with additional variation from which to identify my relationship of interest.

The literature (e.g. Scholte et al., 2015; Heijmans et al., 2008) have shown that exposure to certain stressors in utero might have differential effects by the trimester of pregnancy. Unfortunately, Statistics Netherlands provides neither quarterly nor monthly provincial unemployment data for the time period of analysis, rendering analysis by trimester impossible. However, for my purposes, yearly data is also appropriate. Firstly, even though trimester of pregnancy might be important for other outcomes, the mechanism that is considered in this paper is acute stress that ultimately leads to the birth by CD, accordingly I am only interested in the time period around birth. Second, as can be observed in Fig. 3, the economic cycles tend to be longer than one year – the upwards or downwards trends in unemployment tend to remain in place for several years. Therefore, apart from seasonal fluctuations, large variation in unemployment rates between trimesters seems unlikely. Third, it is possible that the yearly average unemployment level is high due to a sudden increase in unemployment in the

Table 1A
Descriptive statistics, sample born 1970–1993, all births.

Variable	Obs	Mean	Std. Dev.	Min	Max
Provincial unemp.	28010	6.216	3.578	0.9	13.8
Male	28010	0.392	0.488	0	1
Cesarean delivery	28010	0.042	0.201	0	1
female	17040	0.042	0.201	0	1
male	10970	0.043	0.202	0	1
Birth year	28010	1978.5	6.274	1970	1993
Age mom <20	28010	0.024	0.152	0	1
Age mom 20-25	28010	0.256	0.437	0	1
Age mom 25-30	28010	0.433	0.495	0	1
Age mom 30-35	28010	0.213	0.410	0	1
Age mom 36+	28010	0.074	0.261	0	1
Mother smoked	28010	0.263	0.440	0	1
Immigrant parent	28010	0.034	0.182	0	1

Table 1B
Descriptive statistics, sample born 1970–1993, weekend and holiday births.

Variable	Obs	Mean	Std. Dev.	Min	Max
Provincial unemp.	7573	6.116	3.550	0.9	13.8
Male	7573	0.395	0.489	0	1
Cesarean delivery	7573	0.028	0.165	0	1
female	4584	0.029	0.169	0	1
male	2989	0.026	0.159	0	1
Birth year	7573	1978.2	6.174	1970	1993
Age mom <20	7573	0.025	0.156	0	1
Age mom 20-25	7573	0.265	0.441	0	1
Age mom 25-30	7573	0.432	0.495	0	1
Age mom 30-35	7573	0.207	0.406	0	1
Age mom 36+	7573	0.070	0.256	0	1
Mother smoked	7573	0.267	0.443	0	1
Immigrant parent	7573	0.035	0.184	0	1

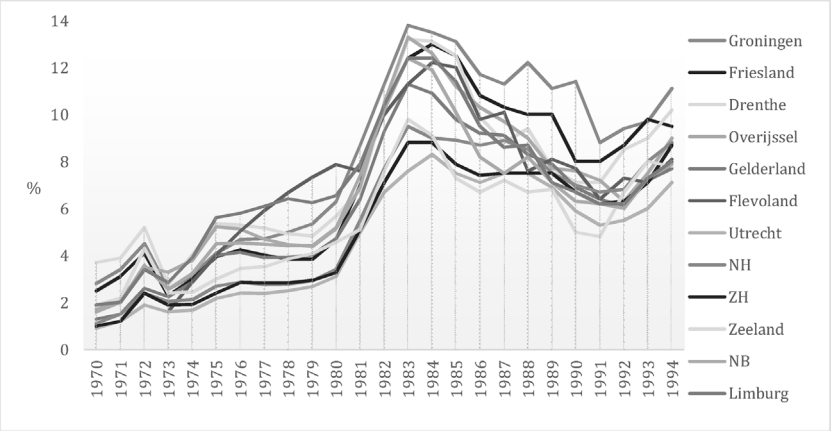

Fig. 3. Provincial unemployment rates in the Netherlands.1970–1993.

second half of the year. In such case, theoretically the births from the first half of the year should be unaffected. However, the literature has shown that workers are able to anticipate financial distress in their companies (Brown and Matsa, 2016). This suggests that even if a birth happens before a sudden increase in unemployment mid-year, the employees might be experiencing stress effects already before the actual increase in unemployment.

3. Methods

I start with a simple Probit specification:

$$P(Y_{ipc} = 1 | u_{pc}, m_i = \Phi(\alpha + \beta_1 u_{pc} + \beta_2 m_i + \beta_3 u_{pc} * m_i)$$

where Y_{ipc} is a binary variable taking value 1 if born via CD, for individual i born in province p and year c; u_{pc} is the unemployment rate in province p and birth year c; m_i is a dummy variable taking value 1 if male and 0 if female, and Φ denotes the cumulative distribution function of standard normal distribution.

A major complication in studying the effects of the business cycle on CD is the possibility that not only the patients respond to economic downturns, but, conceivably also the medical specialists and hospitals can change their behaviors in response to financial pressures (Gruber et al., 1999). However, I would expect that the response of the medical specialists and hospitals is not affected by the gender of the fetus. In contrast, stress affects each gender differently, since male babies have been shown to be more sensitive to maternal stress hormones. Additionally, Dehejia and Lleras-Muney (2004) have shown that during periods of high unemployment, consumption of health-related goods and the time use of pregnant women might change. These changes might potentially have gender specific effects on the probability of CD. However, such effects seem unlikely in a country like the Netherlands, where household income is protected by the generous unemployment benefits and female labor participation rates in this time period are still very low. The low female labor participation means that the time use of pregnant women is not likely to change with increasing unemployment levels. This supports stress as the main driving factor of the gender specific effects of regional unemployment.

In my specification, the coefficient β_1 captures the effect of the business cycle on CD in female infants. This includes any physiological responses but also physician responses to the business cycle or institutional changes that affect both genders similarly. β_1 and β_3 together show the effect in males. Accordingly, the coefficient β_3 measures the excess effect in male infants compared to females that can be attributed to the influence of stress; hence, β_3 is my main parameter of interest.

Further, I extend the model in several ways. First, since both the provincial unemployment rates and CD rates exhibit an upwards trend in the period between 1970 and 1993 (see Figure 1, 2 and 3), I account for time trends by including a linear birth year trend and a second order polynomial in birth year in the specification. Second, I add province fixed effects to account for institutional differences between provinces (for example, some provinces have academic hospitals, where most of the complex cases are transferred to, which means that these provinces naturally have higher CD rates). Third, to check whether the results are sensitive to how the birth year is specified, I include birth year fixed effects and province-specific time trends in the model. Finally, I include the mother's characteristics available in the data, e.g. mother's age at the time of childbirth, whether the mother smoked during pregnancy and parents' immigration status. Since these characteristics are likely to be correlated to the socio-economic status of the family, including them provides suggestive evidence on selection effects. All analyses are performed first in the whole sample and then in the weekend and holiday subsample.

The model is estimated by Probit and the standard errors are clustered at province level because the main explanatory variable is at a province level. Since there are only 12 provinces in the Netherlands[4], the number of clusters is small which means that the estimated standard cluster robust standard errors from the Probit estimator can be downwards biased (Cameron and Miller, 2015; Esarey and Menger, 2018). According to Esarey and Menger (2018), pairs cluster bootstrapped t-statistics (PCBSTs) is an appropriate method to deal with the few cluster problem in my data. This method (as studied by Bertrand et al., 2004; Cameron et al., 2008; Harden, 2011), modifies the standard bootstrapping procedure to sample clusters with replacement, rather than individual observations with replacement, and to sample the test statistic t instead of $\hat{\beta}$. In the results section, I provide the p-values resulting from these t-statistics in addition to the standard cluster robust standard errors. Since this method samples clusters with replacement which in my case are provinces, PCBSTs are not possible in a specification that includes province fixed effects. Therefore, I apply the PCBSTs procedure to the specifications without the province fixed effects in both, the full sample and the weekend and holiday subsample. Note that the estimates are essentially unchanged by adding province fixed effects (see columns (2) and (4) in Tables 2A and 2B). In addition, even though the PCBSTs results in slightly less significant results than standard

[4] The three provinces with smallest number of observations, Limburg, North Brabant and Zeeland, were grouped together so effectively I have 10 clusters.

Table 2A
Cesarean delivery and unemployment at the year of birth.1970–1993.

	(1) CD	(2) CD	(3) CD	(4) CD	(5) CD	(6) CD	(7) CD
Provincial unemployment	0.0419***	0.0116**	0.0089	0.0078***	0.0041	−0.0009	0.0038
	(0.0022)	(0.0047)	(0.0080)	(0.0023)	(0.0050)	(0.0236)	(0.0216)
	0.000	*0.1713*	*0.4880*	–	–	–	–
Male	−0.0374**	−0.0432***	−0.0442***	−0.0436***	−0.0449***	−0.0459***	−0.0461***
	(0.0152)	(0.0158)	(0.0167)	(0.0158)	(0.0166)	(0.0163)	(0.0165)
	0.0106	*0.0059*	*0.0073*	–	–	–	–
Interaction: male*unemployment	0.0072	0.0091*	0.0090*	0.0092*	0.0091*	0.0093*	0.0093*
	(0.0045)	(0.0051)	(0.0051)	(0.0050)	(0.0050)	(0.0051)	(0.0051)
	0.3398	*0.3283*	*0.3312*	–	–	–	–
Birth year		0.0223***	0.0330**	0.0242***	0.0380***		
		(0.0028)	(0.0164)	(0.0019)	(0.0135)		
		0.0015	*0.3113*	–	–		
Birth year squared			−0.0004		−0.0005		
			(0.0005)		(0.0005)		
			0.5466		–		
Province FE				YES	YES	YES	YES
Birth year FE						YES	YES
Province trends in birth year							YES
Constant	−2.010***	−45.87***	−67.08**	−49.67***	−76.89***	−2.048***	−1.956***
	(0.0410)	(5.512)	(32.44)	(3.735)	(26.69)	(0.222)	(0.124)
	0.00	*0.0014*	*0.2980*	–	–	–	–
Average marginal effect of unemployment:							
in males	0.0044***	0.0019***	0.0016***	0.0015***	0.0012***	0.00075	0.0012
	(0.0005)	(0.0004)	(0.0006)	(0.0005)	(0.0004)	(0.0023)	(0.0020)
in females	0.0037***	0.0010**	0.0008	0.0007***	0.0004	−0.0001	0.0003
	(0.0003)	(0.0005)	(0.0008)	(0.0002)	(0.0004)	(0.0021)	(0.0019)
Observations	28,010	28,010	28,010	28,010	28,010	28,010	28,010
Pseudo R2	0.0158	0.0203	0.0204	0.0232	0.0235	0.0245	0.0257
Log-likelihood	−4830	−4808	−4807	−4793	−4792	−4788	−4781
AIC	9668	9626	9626	9598	9596	9594	9580

Note: The table presents results from a probit model analyzing cesarean delivery and unemployment at the year of birth, 1970–1993, with different specifications for province and birth year fixed effects. The dependent variable is binary; value 1, if person was born with a CD. Standard errors are clustered at province level and are presented in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The numbers in italics under the standard errors present the alternative p-values for the test of H_0: $\beta_i = 0$ from Pairs cluster bootstrapped t-statistics (PCBSTs) procedure with 10,000 bootstrap replications for specifications where the procedure was feasible. The PCBSTs results are acquired using the *STATA* command clusterbs.

cluster robust inference, my main conclusions are not changed by applying PCBSTs in the reduced specification, which suggests that the small number of clusters might not dramatically change the validity of standard cluster robust inference.

4. Results

My main results are presented in Tables 2A and 2B with Table 2A representing the results from the whole sample and Table 2B representing the results from the weekend and holiday subsample. Column (1) of Table 2A contains the Probit estimate of the basic model with the clustered standard errors and without any of the extensions. The results show a strong correlation between unemployment level and the probability of CD in women. The interaction term between provincial unemployment and gender has the expected positive sign but is not significant, meaning that the gender differences in the effect of unemployment level on the probability of CD are not significant in this specification. However, this specification does not account for time trends. In Column (2), I include a linear trend in birth year and in Column (3), I include a second order polynomial of birth year in the regression. Even though the coefficients of the unemployment level and the interaction between unemployment and gender have the expected positive signs and are significant using the standard cluster robust standard errors, the results are insignificant if I account for the small number of clusters using the PCBSTs. Further adding province fixed effects and different time specifications do not change this result. It is interesting to note, however, that the size of the coefficient for the interaction term is remarkably stable in all specifications.

As discussed above, only a fraction of the CD in the total sample are unplanned CD and could be affected by stress caused by increased unemployment levels. Therefore, the effect is likely underestimated and the standard errors are too big in this sample. Table 2B presents the results from the weekend and holiday subsample, which contains only unplanned CD. As before, column (1) shows a strong correlation between unemployment level at birth and the probability of CD both, in males and females. In columns (2) to (3) I control also for the time trend by including linear birth year and second order polynomial in birth year. Controlling for the time trend renders the main effect of unemployment (effect in females) insignificant. This indicates that unemployment levels do not have an effect on CD that would affect both genders similarly, including any physiological effects, "delivery on demand" and changes in the behavior of obstetric care specialists and hospitals. Given the setup of the Dutch obstetric care system and the generally low CD rates the non-existence of effect seems plausible. Moreover, some of these effects might be cancelling each other out.

However, the effect in males remains significant. The average marginal effects show that a one percentage point (p.p.) increase in provincial unemployment level at birth on average increases the probability of a CD in males by 0.17 p.p. to 0.18 p.p.. Taking into account the low incidence of CD in the weekends in this time period (2.6% of all weekend and holiday births), this corresponds to a 6.9% increase in the probability of CD at the mean. My main parameter of interest is the gender difference in the effect of unemployment represented by the interaction term. The interaction term in columns (2) and (3) has the expected positive sign and is statistically significant at 5% level using the standard cluster

Table 2B
Cesarean delivery and unemployment at the year of birth, 1970–1993, weekend and holiday births.

	(1) CD	(2) CD	(3) CD	(4) CD	(5) CD	(6) CD	(7) CD
Provincial unemployment	0.0302***	0.0099	0.0085	0.0058	0.0041	0.0208	0.0091
	(0.0072)	(0.0131)	(0.0136)	(0.0117)	(0.0118)	(0.0504)	(0.0631)
	0.0101	*0.5479*	*0.6082*	–	–	–	–
Male	−0.179**	−0.183**	−0.183**	−0.183**	−0.183**	−0.188**	−0.188**
	(0.0750)	(0.0780)	(0.0787)	(0.0796)	(0.0804)	(0.0818)	(0.0828)
	0.0312	*0.0366*	*0.0382*	–	–	–	–
Interaction male*unemployment	0.0183**	0.0195**	0.0194**	0.0198**	0.0198**	0.0203**	0.0205**
	(0.0093)	(0.0098)	(0.0099)	(0.0100)	(0.0100)	(0.0100)	(0.0102)
	0.0712	*0.0784*	*0.0781*	–	–	–	–
Birth year		0.0148***	0.0208	0.0170***	0.0239		
		(0.0056)	(0.0186)	(0.0049)	(0.0179)		
		0.0324	*0.3235*	–	–		
Birth year squared			−0.0002		−0.0003		
			(0.0007)		(0.0007)		
			0.7363		–		
Province FE				YES	YES	YES	YES
Birth year FE						YES	YES
Province trends in birth year							YES
Constant	−2.086***	−31.24***	−43.16	−35.15***	−48.70	−1.651***	−1.465***
	(0.0558)	(10.94)	(36.64)	(9.648)	(35.25)	(0.400)	(0.482)
	0.000	*0.0251*	*0.2992*	–	–	–	–
Average marginal effect of unemployment							
in males	0.0029***	0.0018**	0.0017*	0.0015**	0.0014	0.0025	0.0018
	(0.0007)	(0.0009)	(0.0010)	(0.0008)	(0.0009)	(0.0029)	(0.0038)
in females	0.0020***	0.0007	0.0006	0.0004	0.0003	0.0014	0.0006
	(0.0006)	(0.0009)	(0.0009)	(0.0008)	(0.0008)	(0.0033)	(0.0041)
Observations	7573	7573	7573	7573	7573	7573	7573
Pseudo R2	0.0121	0.0141	0.0141	0.0218	0.0218	0.0294	0.0371
Log-likelihood	−958.8	−957.0	−956.9	−949.5	−949.4	−942.0	−934.6
AIC	1925.6	1924	1925.8	1909	1910.8	1902	1887.2

Note: The table presents results from a probit model analyzing cesarean delivery and unemployment at the year of birth, 1970–1993, with different specifications for province and birth year fixed effects for the subsample born in the weekends and holidays. The dependent variable is binary; value 1, if person was born with a CD. Standard errors are clustered at province level and are presented in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The numbers in italics under the standard errors present the alternative p-values for the test of H_0: $\beta_i = 0$ from Pairs cluster bootstrapped t-statistics (PCBSTs) procedure with 10,000 bootstrap replications for specifications where the procedure was feasible. The PCBSTs results are acquired using the *STATA* command clusterbs.

robust standard errors and at 10% using the PCBSTs. As discussed before, this interaction term likely represents the effect of maternal stress. Since male fetuses reportedly react more sensitively than female fetuses to maternal stress (e.g. Catalano et al., 2005 and 2010), the viability of male fetuses may be threatened more than that of female fetuses and this may lead to more CD following stressful events in male fetuses than female fetuses. With the effect in females accounted for, the interaction term between being male and unemployment rate likely isolates the gender specific effect of stress on the probability of CD in males.

A priori, I suspected that the coefficients might be underestimated in the whole sample compared to the weekend and holiday subsample. Comparing the results in Table 2B to the Table 2A, we observe larger coefficients and smaller p-values in the weekend and holiday sample, confirming this argument.

In columns (4) to (7) of Table 2B I extend the model by adding province fixed effects, birth year fixed effects and province trends in time to check that the results are not sensitive to the way the model is specified. Remarkably, the interaction term, denoting the difference in the effect of unemployment on the probability of CD between males and females remains very stable in all specifications. The main effect on females remains insignificant in these two specifications. The average marginal effect in males is also rendered insignificant by adding the province and birth year fixed effects. Since the main parameter of interest is the interaction term, this insignificance does not affect my conclusions. Apparently, there is some province and birth-year specific variation in the data. As discussed above, this could be related to how physicians change their practice in response to financial pressures created by the business cycle. Nevertheless, the stress effect denoted by the interaction term remains unaffected. Unfortunately, due to the data limitations, it was not possible to calculate the PCBSTs for these extended models. Nevertheless, since the results do not seem to be affected by the way the fixed effects are specified, I do not expect that using PCBSTs would change my conclusions.

Next, it is also possible that instead of a direct effect of the business cycle on male CD, we are observing a change in cohort composition, e.g. that women who become pregnant during periods of high unemployment have different probability of CD than women who become pregnant during periods of low unemployment. For example, Alessie et al., 2018 show that during periods of high unemployment, smoking women in the Netherlands are more likely to postpone pregnancy non-smoking women. Moreover, Westert et al. (2003) have demonstrated the socio-economic gradient also in the probability of CD in the Netherlands.

To establish such selection effects, one would ideally need information on the characteristics of the mother that are correlated to the regional unemployment levels and to the probability of CD. Even though *Lifelines* provides very little information about the parents of the individual, I exploit the three pieces of information that I have – mother's age at childbirth and whether she smoked during pregnancy as well as the parents' immigration status. As discussed further, all these characteristics are strongly correlated to the probability of CD and Tables 4A and 4B shows also some correlations to the unemployment levels. Moreover, these variables are likely correlated to the socio-economic status of the mothers. For example, women with lower socio-economic status tend to have the first child earlier and are more likely to

smoke during pregnancy. In addition, families with at least one parent who is born outside the Netherlands have, on average, lower SES. To sum up, even though these variables are only crude proxies of SES, I would expect that they pick up some variation in the cohort composition and, if changes in cohort composition explain the results in Tables 2A and 2B, then adding these controls to the specification would change the coefficients of the main result.

Tables 3A and 3B present the results in the whole sample and the weekend and holiday subsample, respectively. The results in Tables 3A in indicate that, in the whole sample, the probability of CD increases with mother's age and it is higher for smoking mothers and immigrant families, as expected. After accounting for the parental characteristics, the magnitude of the impact of unemployment level on the probability of CD is slightly reduced. However, the interaction term between unemployment and being male, denoting the excess effect in males becomes statistically insignificant in all specifications even with the standard cluster robust standard errors, although the size of the coefficient is affected only marginally.

To better understand this change, in Table 4A, I regress each of the maternal characteristics on provincial unemployment, province fixed effects and birth year fixed effects in the whole sample. The results show that when unemployment is high, male and female babies are less likely to be born to very young mothers. This is in line with the economic theory that predicts that low socio-economic status women with no access to credit are more likely to postpone pregnancy when income is low (see Alessie et al., 2018, for a more thorough analysis). However, since young mothers have a lower probability of CD, this cannot explain the reduction in coefficients in Tables 3A. The last column of Table 4A shows that male babies are also less likely to be born to immigrant parents when unemployment is high. Since these children are more likely to be born by CD, this decrease explains the slight decrease in the coefficients of unemployment in Tables 3A when maternal characteristics are added to the model.

The results from the weekend and holiday subsample in Tables 3B show that mother's age has a smaller coefficient than in the full sample. The mother's smoking status has no significant effect on the probability of CD in the weekends. The coefficients even have the opposite sign compared to the results in Tables 3A. It is possible that the age of the mother and smoking status are risk factors for CD that the physicians take into account when deciding on the optimal manner of birth, thus they affect the probability of a planned CD more than the probability of an unplanned CD during the weekend. However, parents' immigrant status has a larger and more significant coefficient in the weekend subsample than in the whole sample. Nevertheless, in the weekend and holiday subsample the coefficient of the interaction term between unemployment level and gender remains unaffected by adding the mother's characteristics to the model. Further analysis in Table 4B shows that the only change in cohort composition in this subsample that happens when unemployment increases is an increase in the probability of having a smoking mother. However,

Table 3A
Cesarean delivery and unemployment at the year of birth, controlling for mother's characteristics, 1970–1993, all births.

VARIABLES	(1) CD	(2) CD	(3) CD	(4) CD	(5) CD	(6) CD	(7) CD
Provincial unemployment	0.0403***	0.0127***	0.0094	0.0088***	0.0043	−0.0022	0.00514
	(0.0023)	(0.0047)	(0.0082)	(0.0023)	(0.0051)	(0.0231)	(0.0215)
Male	−0.0307**	−0.0360**	−0.0375**	−0.0365**	−0.0385**	−0.0397**	−0.0399**
	(0.0148)	(0.0164)	(0.0179)	(0.0156)	(0.0171)	(0.0173)	(0.0176)
Interaction: male * unemp	0.0067	0.0085	0.0084	0.0086	0.0085	0.0088	0.00881
	(0.0050)	(0.0057)	(0.0057)	(0.0055)	(0.0055)	(0.0056)	(0.0056)
Age mother <20	−0.393***	−0.367***	−0.367***	−0.371***	−0.372***	−0.372***	−0.376***
	(0.102)	(0.103)	(0.105)	(0.101)	(0.104)	(0.100)	(0.101)
Age mother 20-25	−0.373***	−0.358***	−0.362***	−0.358***	−0.363***	−0.364***	−0.366***
	(0.0352)	(0.0353)	(0.0390)	(0.0342)	(0.0376)	(0.0381)	(0.0381)
Age mother 25-30	−0.282***	−0.286***	−0.290***	−0.289***	−0.294***	−0.294***	−0.293***
	(0.0385)	(0.0424)	(0.0467)	(0.0429)	(0.0465)	(0.0473)	(0.0472)
Age mother 30-35	−0.163***	−0.179***	−0.181***	−0.182***	−0.184***	−0.185***	−0.186***
	(0.0452)	(0.0516)	(0.0535)	(0.0522)	(0.0539)	(0.0557)	(0.0555)
Mother smoked	0.0869***	0.0916***	0.0893***	0.0920***	0.0891***	0.0891***	0.0886***
	(0.0196)	(0.0203)	(0.0194)	(0.0228)	(0.0220)	(0.0214)	(0.0214)
Immigrant parent	0.128**	0.122**	0.120**	0.117**	0.114*	0.113*	0.112*
	(0.0512)	(0.0561)	(0.0580)	(0.0595)	(0.0609)	(0.0615)	(0.0620)
Birth year		0.0206***	0.0340**	0.0226***	0.0394***		
		(0.0030)	(0.0174)	(0.002)	(0.0143)		
Birth year squared			−0.0005		−0.0006		
			(0.0006)		(0.0005)		
Province FE				YES	YES	YES	YES
Birth year FE						YES	YES
Province trends in birth year							YES
Constant	−1.778***	−42.33***	−68.89**	−46.28***	−79.48***	−1.825***	−1.731***
	(0.0129)	(5.949)	(34.24)	(3.949)	(28.26)	(0.215)	(0.120)
Average marginal effect of unemployment							
in males	0.0042***	0.0019***	0.0016***	0.0016***	0.0012***	0.0006	0.00125
	(0.0006)	(0.0004)	(0.0006)	(0.0005)	(0.0004)	(0.0022)	(0.002)
in females	0.0035***	0.0011**	0.0008	0.0008***	0.0004	−0.0002	0.0004
	(0.0003)	(0.0005)	(0.0008)	(0.0002)	(0.0004)	(0.002)	(0.0019)
Observations	28,010	28,010	28,010	28,010	28,010	28,010	28,010
Pseudo R2	0.0228	0.0266	0.0268	0.0296	0.0299	0.0308	0.0321
Log-likelihood	−4795	−4777	−4776	−4762	−4761	−4756	−4750
AIC	9608	9572	9570	9542	9540	9530	9518

Note: The table presents results from a probit model analyzing cesarean delivery and unemployment at the year of birth, 1970–1993, with different specifications for province and birth year fixed effects. The dependent variable is binary; value 1, if person was born with a CD. Standard errors are clustered at province level and are presented in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The reference category for mother's age is older than 35.

Table 3B
Cesarean delivery and unemployment at the year of birth, controlling for mother's characteristics, 1970–1993, weekend and holiday births.

	(1) CD	(2) CD	(3) CD	(4) CD	(5) CD	(6) CD	(7) CD
Provincial unemployment	0.0288***	0.0112	0.0091	0.0068	0.0043	0.0222	0.0134
	(0.0076)	(0.0134)	(0.0136)	(0.0121)	(0.0118)	(0.0496)	(0.0641)
Male	−0.180**	−0.183**	−0.182**	−0.183**	−0.183**	−0.187**	−0.188**
	(0.0738)	(0.0769)	(0.0778)	(0.0783)	(0.0793)	(0.0806)	(0.0810)
Interaction: male * unemp	0.0173*	0.0183*	0.0182*	0.0187*	0.0186*	0.0191*	0.0193*
	(0.0094)	(0.01)	(0.0101)	(0.0102)	(0.0103)	(0.0102)	(0.0103)
Age mother <20	−0.312	−0.298	−0.301	−0.298	−0.301	−0.297	−0.301
	(0.324)	(0.324)	(0.326)	(0.320)	(0.322)	(0.312)	(0.312)
Age mother 20-25	−0.222***	−0.214***	−0.217***	−0.217***	−0.221***	−0.219***	−0.233***
	(0.0582)	(0.0567)	(0.0601)	(0.0528)	(0.0569)	(0.0590)	(0.0622)
Age mother 25-30	−0.149	−0.153*	−0.157*	−0.160*	−0.164*	−0.166*	−0.162*
	(0.0925)	(0.0878)	(0.0885)	(0.0846)	(0.0859)	(0.0865)	(0.0894)
Age mother 30-35	−0.0831	−0.0970	−0.0996	−0.102	−0.105	−0.102	−0.108
	(0.0679)	(0.0687)	(0.0646)	(0.0743)	(0.0700)	(0.0751)	(0.0764)
Mother smoked	−0.0413	−0.0388	−0.0403	−0.0398	−0.0415	−0.0373	−0.0292
	(0.0408)	(0.0391)	(0.0378)	(0.0431)	(0.0416)	(0.0415)	(0.0412)
Immigrant parent	0.177**	0.180**	0.179**	0.187**	0.186**	0.190**	0.187**
	(0.0762)	(0.0756)	(0.0771)	(0.0760)	(0.0766)	(0.0793)	(0.0821)
Birth year		0.0131**	0.0221	0.0154***	0.0255		
		(0.0061)	(0.0180)	(0.0054)	(0.0172)		
Birth year squared			−0.0004		−0.0004		
			(0.0007)		(0.0007)		
Province FE				YES	YES	YES	YES
Birth year FE						YES	YES
Province trends in birth year							YES
Constant	−1.928***	−27.73**	−45.53	−31.86***	−51.74	−1.489***	−1.290***
	(0.0787)	(12.07)	(35.49)	(10.56)	(34.00)	(0.404)	(0.476)
Average marginal effect of unemployment							
in males	0.0027***	0.0018**	0.00162	0.0015**	0.0014	0.0024	0.0019
	(0.0007)	(0.0009)	(0.001)	(0.0007)	(0.0009)	(0.0029)	(0.0038)
in females	0.0019***	0.0007	0.0006	0.0004	0.0003	0.0015	0.0009
	(0.0006)	(0.0009)	(0.0009)	(0.0008)	(0.0008)	(0.0033)	(0.0042)
Observations	7573	7573	7573	7573	7573	7573	7573
Pseudo R2	0.0158	0.0173	0.0174	0.0251	0.0252	0.0327	0.0405
Log-likelihood	−955.2	−953.8	−953.7	−946.3	−946.2	−938.8	−931.3
AIC	1928.4	1925.6	1927.4	1910.6	1910.4	1895.6	1880.6

Note: The table presents results from a probit model analyzing cesarean delivery and unemployment at the year of birth, 1970–1993, with different specifications for province and birth year fixed effects for the subsample born in the weekends and holidays. The dependent variable is binary; value 1, if person was born with a CD. Standard errors are clustered at province level and are presented in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The reference category for mother's age is older than 35.

since mother's smoking status does not have a significant effect on the probability of CD, this change in cohort composition does not affect the results. In sum, the relationship between stress caused by high unemployment and the probability of CD cannot be explained by selection into fertility based on the available parental characteristics.

Additionally, I have performed several robustness analyses for the results. The results are robust to excluding the earlier years of the data, when there are more missing values. Also, the results are robust to excluding the last years, when the sample sizes are smaller. The results are not affected by including a lagged provincial unemployment rate to account for longer exposures to high unemployment rates and by including a municipal level deprivation measure to account for regional SES differences. The results of these analyses are available on request.

Table 4A
Cohort composition and unemployment at the year of birth, 1970–1993, all births.

VARIABLES	(1) Age mother <20	(2) Age mother 20-30	(3) Age mother >30	(4) Mother smoked	(5) Immigrant parent
Males					
Provincial unemployment	−0.201***	−0.0034	0.0200	−0.0053	−0.0408**
	(0.0616)	(0.0203)	(0.0213)	(0.0252)	(0.0179)
Observations	10,549	10,970	10,970	10,970	10,970
Females					
Provincial unemployment	−0.0626**	0.0056	0.0034	0.0122	0.0011
	(0.0287)	(0.0097)	(0.0083)	(0.0164)	(0.0196)
Observations	16,649	17,040	17,040	17,040	17,040
Province FE	YES	YES	YES	YES	YES
Birth year FE	YES	YES	YES	YES	YES

Note: The table presents results from a probit model analyzing cohort composition and unemployment at the year of birth, 1970–1993, including province and birth year fixed effects for the whole sample. The dependent variable is binary; value 1, if the mother belongs to the particular group. Standard errors are clustered at province level and are presented in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4B
Cohort composition and unemployment at the year of birth, 1970–1993, weekend and holiday births.

VARIABLES	(1) Age mother <20	(2) Age mother 20-30	(3) Age mother >30	(4) Mother smoked	(5) Immigrant parent
Males					
Provincial unemployment	−0.195	−0.0439	0.0571	0.0793*	−0.0133
	(0.167)	(0.0352)	(0.0382)	(0.0412)	(0.0570)
Observations	2,448	2,989	2,989	2,989	2,917
Females					
Provincial unemployment	−0.0218	0.0198	−0.0184	0.0741***	0.0445
	(0.0765)	(0.0227)	(0.0317)	(0.0217)	(0.0314)
Observations	4,134	4,584	4,584	4,584	4,584
Province FE	YES	YES	YES	YES	YES
Birth year FE	YES	YES	YES	YES	YES

Note: The table presents results from a probit model analyzing cohort composition and unemployment at the year of birth, 1970–1993, including province and birth year fixed effects for the subsample born in the weekends and holidays. The dependent variable is binary; value 1, if the mother belongs to the particular group. Standard errors are clustered at province level and are presented in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5. Conclusions

In this paper, I analyze the effect of provincial unemployment level on the probability of being born via Cesarean Delivery (CD) using data from *Lifelines* – a large cohort study from the north of the Netherlands. I am especially interested in the effect on male CD since a general effect of unemployment on the probability of CD might be driven by both – physiological responses to economic downturns and the reactions by obstetric care providers, while any excess effect in males is most likely driven by a biological response to economic stress.

I find that the probability of CD in females does not increase when the economy declines. However, male CD increases in excess of female CD when unemployment levels rise. This finding is in line with the results of Bruckner et al. (2014) and supports the general hypothesis on male fetal sensitivity to stressors in utero. The maternal response to increased unemployment levels may elicit clinical signs of distress in male fetuses upon which medical staff may intervene. Moreover, these results support the findings on birth weight by Alessie et al. (2018) who find that during periods of high unemployment boys are born with lower birthweight. In addition, the results do not seem to be driven by selection into fertility. Even though cohort composition changes when unemployment increases, this does not explain the results of this paper. Since CD is a costly medical procedure, an increase in the male CD rates represents not only a health effect but also a direct cost of economic downturns. Since CD is only a proxy for fetal distress and not a health outcome by itself, future research should examine whether the increased probability of CD also leads to adverse short and long term health outcomes as well as attempt to quantify the effect of maternal stress at birth on health outcomes.

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Appendix A. Supplementary data

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